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## Investigation of anode materials for lithium-ion batteries|

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# **Investigation of Anode Materials for Lithium-ion Batteries**

A thesis submitted in fulfillment of the requirements  
for the award of the degree

**Doctor of Philosophy**

From

University of Wollongong

By

**Ling Yuan, M. Sc., B. Sc.**

**Institute for Superconducting and Electronic Materials**

**Faculty of Engineering**

**2006**

## **CANDIDATE’S CERTIFICATE**

This is to certify that the work presented in this thesis is original and was carried out by the candidate at the laboratories of the Institute for Superconducting and Electronic Materials, the Faculty of Engineering, University of Wollongong, New South Wales, Australia, and has not been submitted for a degree to any other university or institution.

**Ling Yuan**

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## ABSTRACT

The aim of this study is to investigate various novel anodes for the lithium ion secondary battery. Lithium ion batteries are currently the best portable energy storage devices for the consumer electronics market. Large capacity, good cyclability, and no reaction with electrolytes are indispensable characteristics for lithium ion battery anodes. The recent development of lithium ion batteries has been achieved by the use of selected carbon and graphite materials as anode. Therefore, carbon based materials have been the main candidates for commercial use. However, many efforts have been aimed at finding potential substitutes for carbon based materials.

Tin oxide has been a popular candidate material for lithium ion battery anodes since it was discovered. In this study, it was prepared by an in-situ spray pyrolysis technique, and the electrochemical properties were examined in detail. The resultant spherical porous SnO<sub>2</sub> anode shows superior electrochemical properties, i.e. a large initial capacity (601 mAh/g) and excellent cyclability. The retained capacity up to 50 cycles is 68.2% of the initial capacity, which is far superior to any previous SnO<sub>2</sub> electrode. To avoid the capacity fading after the first discharge, carbon or polymer polypyrrole were added to produce tin oxide based nanocomposite materials as described in the following chapters. Improved reversible capacity performance was achieved by using these approaches. The SnO<sub>2</sub>-carbon composites showed a significantly improved cycle-life performance compared with SnO<sub>2</sub> without carbon. The conductive polypyrrole also serves as a conducting matrix to buffer the active material in the composite and thus to reduce the



volume change associated with  $\text{Li}_x\text{Sn}$  alloying and dealloying reactions. The cyclability was improved compared to bare  $\text{SnO}_2$  anodes.

Some transition metal oxides also show excellent potential for lithium ion batteries. Nanostructured cobalt, or nickel oxide composites are promising substitutes for graphite anodes. Therefore, they were synthesized by different novel methods in this study, and their electrochemical properties for lithium ion batteries were explored systematically. Electrochemical measurements showed that the NiO nanoshaft cluster electrodes could be charged and discharged reversibly with high capacities and superior cycling reversibility. The as-prepared  $\text{Co}_3\text{O}_4$  also demonstrates high lithium storage capacity and promising cycle-life as an electrode material for Li-ion batteries.

Furthermore, mesoporous gold sponges were employed as anode materials for the lithium ion battery for the first time. The multilayer mesoporous Au electrode showed superior discharge capacities and better cycling stability than thin, solid gold film. The mesoporous structure of the Au probably contributes to accommodating the large volume changes in the electrode that occur during alloying and dealloying, which can reduce the fading in capacity to some extent.

Therefore, all of these novel anode materials are unique and good substitutes for traditional carbonaceous anodes for lithium ion batteries.